the finer branches of the glosso-pharyngeal, accessory, and hypoglossal nerves. Neither paper is capable of abstract, while the adoption of the Wilderian adjectives and adverbs renders them somewhat pedantic and obscure.

Dr. Frederick Tuckerman has recently published several articles upon the taste organs of mammals. In the *Anatomischer Anzieger* occur descriptions of these organs in *Putorius vison*, (Vol. III., p. 941), *Arctomys monax*, (Vol. IV., p. 334), *Perameles nasuta*, (Vol. IV., p. 441). In the latter he finds lateral taste areas overlooked by Poulton. In the *American Journal of Science* for October, 1889, he describes the organs in the common hare. In the *Journal of Anatomy* occur accounts of the taste organs in *Vulpes vulgaris* (Vol. III., p. 201).

Leboucq (*Anat. Anz.*, IV.) finds that on the digits of the fins of fœtal Sirenia and Cetacea there are evident traces of claw-forming epithelium. On the dorsal surface of each digit there is an insinking of the epidermis like that which precedes the formation of nails and claws in other mammalia, but no claw is formed by it.

EMBRYOLOGY.

The Development of Micrometrus aggregatus, one of the Viviparous Surf-perches.—At a recent meeting of the San Diego (Cal.) Medical Society, Dr. C. H. Eigenmann presented the results of his further studies upon the early viviparous development of the very minute ova of *Micrometrus aggregatus*. The differences in the modes of segmentation were pointed out, and a comparison of the embryonic membranes of the different major types of amniotic vertebrates was made. The effect of the loss of a large food-yolk, as illustrated upon comparing the egg of a mammal and a bird, was shown to resemble a similar loss of food-yolk in the eggs of Micrometrus as compared with other large-yolked oviparous fish eggs. [The eggs of *Micrometrus aggregatus* are the smallest fish ova yet described, measuring only a little over 1-140th of an inch, or less than those of most mammalia, thus showing the profound influence of viviparity in causing a diminution in the size of ova.]

The following are Dr. Eigenmann's most recent observations :—

The average pelagic fish egg has a diameter of about 1 mm. ; only

a very minute portion of which segments and takes part in the formation of the embryo. The egg is deposited by the mother in the water, where it lies or swims unprotected. As the tail of the young fish is formed it begins to move, first feebly and then vigorously, until the membrane surrounding the egg is burst and the young fish swims out. At the time of hatching the intestinal tract is still very rudimentary, the food, until the intestines are more fully developed, being supplied by the large mass of yolk stored in the egg. The tail is at this time quite free from the yolk, and it is usually fringed by a broad, thin membrane which serves as a fin.

The development of Micrometrus differs from the usual mode in some very essential characters, as this form belongs to a family of viviparous fishes almost exclusively confined to the west coast of North America. All the members of this family give birth to their young in an advanced stage. Micrometrus has gone further in this peculiar line of development than the other members of the family with the exception of *Abeona minima.* The ovary of the former consists of a spindle-shaped tube, from the dorsal wall of which are suspended six broad, thin sheets of membrane, in which are scattered comparatively few ova. At the time the eggs are ripe the ovary is no thicker than a goose quill, and the oviferous tissues are folded upon themselves. With the growth of the embryos the walls of the ovary become greatly distended, the oviferous sheets unfolding at the same time.

To follow the development of a single egg: While still in the tissues in which it was developed it measures .24 mm. in diameter, is opaque, and contains a germinal vesicle. At the time of ripening the egg contents shrink to less than half their original volume, the germinal vesicle disappears, and the protoplasm of the ovum is separated from the yolk or food material, the whole contents of the egg measuring at the end of this shrinking but .18 mm. in diameter. By comparing this diameter with that of the average fish egg, it will be noticed that the volume of this is more than 100 times less than that of the ordinary fish egg. This reduction is not merely mechanical; it is due to the non-formation of yolk, which has been reduced to a small particle lying at one side of the comparatively large mass of protoplasm, forming the germinal mass, which segments at once after impregnation.

This non-formation of food yolk may be explained in the following manner; taking it for granted that the embryo will be supplied with all the necessary food by the mother. The ovary of the typical fish passes through a state of physiological rest and a state of physiological

activity. The resting stage begins immediately after the spawning; the active stage begins a few months before spawning and culminates at spawning. During the resting period the eggs contained in the ovary do not perceptibly increase in size, while during the active stage they double their volumes many times.

In Micrometrus the active period begins when the eggs are ripe, and culminates at the time the young are set free. In other words, the eggs become ripe when in ordinary fishes they only begin their most active growth. Now the yolk of normal fish eggs is found chiefly during the time of rapid growth; maturation of the egg of Micrometrus being hastened several months, and occurring at the beginning of active growth, it is matured with but little yolk.

In the young eggs of Micrometrus there lies a small nucleus exterior to the germinal vesicle. This nucleus increases in size, and in the ripe egg lies directly at the vegetative pole of the egg. A similar structure is seen in Abeona.

At or near the time of the shrinking of the egg it is freed from the ovarian follicle in which it was developed. By the shrinking of the egg a large chamber is formed between it and the membrane surrounding it. About this time fertilization probably takes place.

The spermatozoa deserve more than a passing notice. They are composed of a rod-shaped head and a long vibratile tail. Large numbers of them are found in the ovary, and the conditions for their continual activity being favorable they live in the ovary several weeks, very probably until they are digested by the young fish. They seem to increase in activity with their stay in the ovary. Their rapid motion keeps the fluid secreted by the ovary in constant circulation. This circulation is undoubtedly taken advantage of by the young, it bringing a large amount of oxygenated mucus in contact with them. If the spermatozoa were not present other arrangements for the circulation of the mucus would have to be provided, or the embryos and early larvæ would undoubtedly be asphyxiated.

The spermatozoa seem to have a triple function. First, the normal one of fertilizing the egg; second, to circulate the mucus and thereby to ærate the embryo; third, to act as pabulum to the larvæ as soon as the digestive tract is sufficiently developed.

The segmentation as far as observed is normal. It is apparent, however, that *inherited tendencies only keep the egg from segmenting totally.* The stages from the completion of segmentation to hatching are not yet understood.

The embryo at hatching is in a very rudimentary condition. The tail is not yet free from the yolk and is in contact with the head. The tissues over the base of the yolk lengthen and the embryo begins to straighten itself. The tail does not begin to grow out until some time later. Several days are undoubtedly consumed after hatching in reaching the equivalent stage of oviparous fishes at the time of hatching.

The hastening in hatching is due to the absorption by the embryo of food supplied by the ovary. The embryo thus soon fills the cavity left between the egg and the membrane at maturation, and the membrane then bursts. The hatching process is therefore decidedly different from the hatching of oviparous fishes.

If the newly-hatched oviparous fish is compared with the corresponding stage in Micrometrus another ancestral trait will be discovered in the latter. While the yolk in the latter is minute as compared with that of the former, the *yolksack is just as large.* The yolk fills but a very small portion of it; almost all the yolksack is occupied by the enormous pericardial chamber through which the thin tubular heart passes upward and forward.

The development of the whole family of fishes of which Micrometrus is a representative (the Ditremidæ) is characterized by the hypertrophy of the hind gut, first pointed out by Ryder. This is already well developed at hatching, and at the time Kupffer's vesicle appears it very probably extends considerable beyond the point where the latter is situated. In all stages until the last this hind gut protrudes greatly from the ventral profile.

Yolk absorption is not completed until quite late in the development, that is, not until the embryo has reached a stage homologous with the corresponding stage of oviparous fishes at the time of the completion of yolk absorption. That the yolk is not sufficient to account for a tithe of the growth of the embryo during this time goes without saying. The delay in the total absorption of the yolk is simply another trait inherited from oviparous ancestors.

The food absorption is of considerable interest. The earliest absorption is undoubtedly similar to the preplacental absorption of food by the embryos of placentalian mammals. At the time the embryo has developed a tail and circulation, and before the mouth is open, the first gill slit is open, and *a continuous stream of mucus mixed with spermatozoa enters the intestinal tract at this point, and passes out of the anus apparently unchanged.*

With the opening of the mouth villi appear in the hind gut. Food secreted by the ovary is now taken in through the mouth, and can be

seen to fill the anterior intestine and extend into the posterior intestine as a solid rod, usually terminating in a knob. It is very probable that the primitive absorption does not cease with the opening of the mouth, and that even after the villi are formed it is carried on by the now highly vascular fins. The larvae are at no time connected with the ovary.

Next to the feeding, the aeration is of great importance. The ovarian structures are well supplied with blood vessels, and the mucus contained in the ovary is undoubtedly oxygenated by osmosis, while spermatozoa keeps the mucus in circulation. There is, then, nothing further to explain as respects the early stages, the conditions being similar to those obtaining in pelagic eggs. With the growth of the fins they become highly vascular, the blood vessels occupying much more space than the remaining structures of the fin membrane. The fins also are several times as large as they are in the adult, and the tips of the membranes are continued beyond the ends of the rays. The fins therefore offer a very large surface in which osmotic action may take place. A similar network of capillaries is formed over the whole surface of the body. At this time also the ovary has become greatly distended, and the inner oviferous sheets have become unfolded. The fins can therefore lie directly against the vascular structure of the ovary, and osmosis takes place directly between the blood of the mother and the blood of the young.

About twelve young are born at one time. Seven or eight months after the young are born they are sexually mature, and contain embryos.—C. H. EIGENMANN, *San Diego, Cal., Feb 8, 1890.*

On a Brood of Larval Amphiuma.—During the last two or three years the writer has been endeavoring to obtain larval Amphiumidæ. Recently, Prof. Edmond Souchon, of Tulane University, New Orleans, La., has been enabled to obtain some advanced larvæ for me, in the egg, which he has very generously placed at my disposal. As already described by Hay, the eggs are joined together by a narrow cord formed of the same material as the egg-coverings. Most of the embryos had escaped from the eggs when they reached me, and, owing to the long journey they had made, were dead, though they were in a fairly good condition for study after proper treatment with Kleinenberg's fluid.

What has surprised me is the variation in size of these embryos. Though all have evidently only just escaped from the egg, and have not had any opportunity to feed, there is a marked diversity in their

length and size. The smallest specimens measure 38 mm., while the largest measure 54 mm., and are correspondingly robust as compared with the smaller individuals. All have apparently absorbed the yolk, since there is no external evidence of a yolk sack in any case. Whether this indicates that the egg varies in size when laid, cannot, of course, be determined until further opportunity is afforded to obtain still earlier stages.

In those specimens which are best preserved, the skin presents certain features which do not appear to have been noticed by others, viz.: the presence of a system of lateral line organs, which differ somewhat in arrangement from those of other urodelous batrachia. There are three rows of end organs on the sides, as in other Urodeles. Of these the uppermost one is faint, and lies close to the middle one. The median one extends along the entire length of the sides, and over the sides of the tail. The lowermost row is most widely separated from its fellows of the same side, and extends only from the axilla to the groin, as usual in other forms.

With respect to the terminal or end organs on the head, they are much less conspicuously developed than in other Urodeles, and there appear to be no distinct rows of them externally along the course of the hyoid and branchial arches, as in *Amblystoma*.

The smallest as well as the largest individuals have the limbs developed, and all have three toes, so that the limbs are evidently as fully developed as they will ever be at the time of hatching. In this respect *Amphiuma* differs not only from all other limb-bearing Urodeles, but from the *Anura* as well. The fore and hind limbs also seem to be developed almost or quite synchronously, a feature which is unusual also.

There are three short, slightly plumose branchiæ set in an oblique row on either side of the back part of the head. There is nothing to indicate that they differ very widely from those of the larvæ of *Amblystoma* in their histological structure.

The general color of the smaller individuals is darker than that of the larger ones. The smaller specimens are blackish brown, the largest ones somewhat paler and also lighter on the under side of the body. Some specimens have a very narrow colorless stripe running along the median line of the belly.—John A. Ryder.

The Acquisition and Loss of Food-Yolk, and Origin of the Calcareous Egg-shell.—The discovery of a form of *Peripatus* with a minute egg, without yolk, and a sort of placental development,

as well as the discovery made by Mr. Eigenmann that the ovum of the viviparous surf-perches is almost completely yolkless, resulting in a reduction in volume of the whole ovum to such an extent as to be paralleled in size only by the ova of the more prolific lower forms and those of mammals, goes far toward giving us the requisite data for a reinvestigation of the causes leading to the diminution and loss of the food-yolk, after the latter had once been acquired, as must have been the case in *Peripatus*, *Micrometrus*, and the *Mammalia*.

The ova of primitive types were almost wholly without yolk. The surplus nutriment of such forms was at once elaborated into a great number of small ova, so that the chances of survival were augmented by the great fertility thus attained by a species, which was without the means for affording its young any protection.

If, however, owing to some such circumstance as an unusual abundance of food, the individual ova of the same species would either tend to be multiplied in number in the ovary, or the individual ova would tend to increase in size, it might even happen that they would become the depositories in which surplus oils or other hydrocarbons would be stored up, as actually happens in the case of fish eggs, thus leading through a common histological process, such as that witnessed in the formation of ordinary adipose tissue, to the evolution of an egg capable of floating at the surface of the water as happens in the case of pelagic fish ova. Such a result doubtless would contribute powerfully toward favoring the survival of a species provided with such floating ova, which we thus perceive may have arisen as a consequence of the action of natural causes, not having specifically as their end the salvation of the species, but rather the disposition of a surplus of material elaborated by the female organism and sent to the ovary.

If, further, the parent female organism became more highly developed, more intelligent, circumspect, and alert, the ability to obtain nutriment would be increased, but with this increase of powers the ovary becomes, as a matter of fact, reduced in dimensions, and there is further nothing to prevent one's assuming that the most favorably situated ova would receive the most nutriment and reach the largest size. Diminution of the ovary would tend to limit the number of ova to be nourished, and thus increase their size. If, furthermore, the female parent became circumspect, the tendency would be to retain the eggs in the oviduct until a favorable opportunity was offered for their deposit. If such retention were prolonged, as occurs in reptiles, for a considerable time, there would first of all tend to be deposited albuminous or plasmic secondary deposits, or secondary membranes, or even

a calcareous shell would tend to be formed as the result of the normal secretory activity of the oviduct, inherited from still lower forms. In this way alone is it possible to conceive of the evolution of the egg-shell of such forms of reptiles and birds. The secretory activity thus diverted from depositing surplus nutriment in the ovary would inevitably tend to diminish the fertility of the individual female, and starve the remaining ova in the ovary, unless active feeding went on during and after the period of the retention of the already formed ova in the oviduct.

Now suppose a still further advance on this process, as a result of which not only the egg but the embryo is developed and nourished in the reproductive passages. Any further ova which are now detached from the ovary after fertilization has occurred under these new circumstances, and as a result of copulation, cannot be fertilized, but must be resorbed. The growing embryo in the oviduct is also now diverting the whole of the spare nutriment to itself from the ovary, and thus tending to starve any other young ova which it may still contain. The consequence is that the physiological conditions established by either the retention of ova for an unusual period, or the viviparous development of the embryo through its retention in the oviduct, would directly tend to bring about, first of all, a diminution of fertility, and secondly, as a consequence of viviparity, check the future production of ova or germs for the time being. The result is obviously one which would tend to be self-perpetuating, and at the same time advantageous to the species. For, while the fertility of the species is diminished, the chances of survival are increased, so that the loss suffered in one direction is compensated in another.

Maturation of the ova in the ovary, and their dehiscence in in forms in which the ova are small, is simultaneous for very large numbers. On the other hand, where a large amount of yolk is added, besides an abundance of albumen and one or more secondary egg-envelopes, this simultaneity gives place to a sequence in the maturation of the ova, either singly, one after the other, or a sequence which is expressed in the serial arrangement of the ova in a row or rows in one or both oviducts. The effect of the delay of the ova in the oviducal passages, where they acquire additional material, must be such as to tend to put not only an end to simultaneity of maturation of ova in the ovary, but also from that very circumstance to diminish the absolute fertility of the species as determined by the number of ova matured. That the ovary, as well as testes, have been reduced in length and volume in the higher forms, is certain from the fact discov-

ered by Nagel that the germinal epithelium in the mammalian embryo is much greater in extent than is required for the rudiments of either ovaries or testes. Similar facts are known respecting the development of the ovaries and testes of other forms. In the human female at puberty there are potentially 72,000 ova in the ovaries, yet of these only about 400 can by any possible chance ever become mature in a lifetime, while an average fertile marriage would, instead of increasing, actually reduce the number to 350. This is due to the interference of the process of gestation. So pronounced is this interference in its physiological effects that it leads to the development of a marked difference between the corpus luteum formed in the ovary in the pregnant and that formed during the non-pregnant condition.

To sum up, the secondary processes of ova-gestation, viviparity, and utero-gestation have tended to diminish the fertility of a species as measured by the whole number of ova produced in a lifetime; but at the same time a great gain was made in the strength, vigor, and opportunity for survival of the offspring. Ova-gestation, all forms of viviparity, except the parthenogenetic, and utero-gestation, are probably the consequences, in the first place, of the acquisition of the ability to effect a fertile union or copulation of the sexes, the impulse toward which probably came originally from the male, where the sexes were distinct.

These processes have also tended to direct nutriment from the ova and ovary to be built up into the embryo in other ways, thus tending to intensify the alecithal or yolkless condition of the other eggs remaining in the ovary; or where a brief ovo-gestation only occurs, as in birds, reptiles, and monotremes, the surplus nutriment has been concentrated upon the few serially matured ova, thus increasing the actual volume of the latter rather than diminishing it. If, however, prolonged utero-gestation supervenes, the opposite effect must follow, and nutriment be continually diverted from the ovary to the uterus, and thus tend to diminish the size of the ova remaining in the ovary. The subsequent period of lactation would tend to prolong this diversion of surplus nutriment from the ovary in mammals.

The fertility of the marsupialia is much greater than that of other mammalia, and the eggs, as was to have been expected from the shorter period of gestation, are also much larger. I have myself removed twenty-two ripe ova from the uteri of a single female of the common Virginia opossum. Other facts with which I have become familiar in a study of the gestation of mice and rats, tend to show that an embryo may develop to a certain extent and then undergo histo-

lytic disintegration and total resorption within the uterine coruna, even after an advanced stage of development has been reached. Dr. Arthur V. Meigs has shown me a series of fine preparations showing such a process, and one of my pupils, Mr. Edward Bancroft, has prepared a series of sections from the uterus of a mouse showing much earlier abortive stages of the embryo, which also indicate that absorption takes place subsequently.

These facts indicate that the fertility of an individual may be reduced by processes of absorption of the whole embryo within the uterus. These phenomena may be associated with the resorption of ova in the ovary, as described by Ruge, to which I can add that such a process of resorption of ova is a common occurrence at the end of the spawning season in the ovary of common sturgeon. These facts further indicate how complex the physiological factors are which determine the size and number of the ova matured by a species during a single season. They also go far toward showing how important it is to consider the effect of the acquisition of certain habits upon the result, such as those of copulation, nidification, stealth, and care in hiding the ova, the latter often being retained for a greater or lesser period of time, until it is convenient or safe to deposit them.

Finally, it may be affirmed that the solution of the question of relative fertility of a species, the acquisition and loss of a food-yolk, is completely beyond the reach of the current "*Ding an Sich*" morphological method. It is also clear that the neglect to study the reproductive habits of a species in connection with its physiological and morphological characteristics is to be condemned. Unless the contrary method is followed, there is no possible clue to the origin of the calcareous egg-shell in the ova of oviparous land vertebrates. There is, moreover, otherwise no hope of connecting the phenomena of ova-gestation with those of utero-gestation; the one must have preceded the other, otherwise the remarkable fact that no well-authenticated case of placentation has ever been made out where there is a large amount of yolk present, also loses its obvious significance, while the development of an outer layer of nutritive epiblast in mammals (trophoblast of Hubrecht, *Deckschicht* of other authors) loses its adaptive import and becomes a mere morphological "*Ding an Sich*," to be shelved and labeled like a rare *bon mot* in the mental cabinet of the specialist.

It may be added, in conclusion, that the *membrana putaminis* of eggs of birds and reptiles is a reticular but cuticular membrane, which is to be regarded as the homologue of the keratose cuticular secondary

oviducal membranes of still lower forms,[1] and that it would tend to take up calcareous matters in the same way as similar membranes in other parts of the body of a vertebrate. (See my paper "A Physiological Theory of the Calcification of the Skeleton," *Proc. Am. Philo. Soc.*, Vol. XXVI., 1889.)—JOHN A. RYDER.

PHYSIOLOGY.

THE American Physiological Society held its annual meeting for 1889 on December 27th and 28th at the College of Physicians and Surgeons in New York. H. P. Bowditch, J. G. Curtis, H. H. Donaldson, H. N. Martin, and S. W. Mitchell were elected as the Council for 1889–1890. The following communications were presented:

1. J. G. Curtis, Methods of demonstrating to a large class: *a.* The automatism of the heart of the turtle; *b.* The contraction of the diaphragm of the dog; *c.* The beating of the heart of the calf in opened thorax.
2. W. P. Lombard, The effect of fatigue on voluntary muscle contraction.
3. R. H. Chittenden, *a.* The influence of alcohol on proteid metabolism; *b.* Some observations on the relative formation of albumose and peptone in gastric digestion.
4. S. J. Meltzer, On the self-regulation of respiration.
5. H. N. Martin, The normal respiratory movements of the frog.
6. G. T. Kemp, *a.* Exhibition of a new chronograph clock; *b.* Exhibition of photographs illustrating the coagulation of blood.

On the Origin of the Central Nervous System of Vertebrates.[1]—Gaskell reviews the work of Leydig and other workers on the homologies between the arthropod and vertebrate nervous systems, and considers the resemblances between these systems, both from an anatomical and a physiological point of view, too strong to be disregarded. As to the brain, all researches indicate the anatomical separation of the brain of the crustacean into three parts, which correspond in relative position to the fore-brain, the mid-brain with the

[1] In which chalazæ are also developed, as in the egg of the common skate of our Eastern coast.

[1] *Brain*, July, 1889.